

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference SCG/LP5872080		See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416) FOR FURTHER ACTION
International application No. PCT/GB00/03279	International filing date (day/month/year) 24/08/2000	Priority date (day/month/year) 24/08/1999
International Patent Classification (IPC) or national classification and IPC B29D28/00		
Applicant CRANFIELD UNIVERSITY et al.		



- This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
- This REPORT consists of a total of 6 sheets, including this cover sheet.

☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

- This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 22/03/2001	Date of completion of this report 06.11.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Foulger, C Telephone No. +49 89 2399 2944 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03279

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-14 as originally filed

Claims, No.:

1-11 as originally filed

Drawings, sheets:

1/8-8/8 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

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☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-11
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-11
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-11
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

**Re Item V : Reasoned statement under Article 35(2) with regard to novelty,
inventive step or industrial applicability.**

1. Document US 1 373 344 (D1), that is considered to be the closest prior art document for claim 1, discloses (applying the wording of present claim 1) a method of moulding a reinforced nodal structure (see column 1, line 12) which includes laying down a reinforcement of constant cross section (see column 2, line 75) in and along the channels (see column 2, lines 70 to 72 and figure 1 and claim 7, line 103) of a nodal mould (see figure 2) and across the nodes thereof to at least partially fill the channels (see claim 7, lines 103 and 104), closing the mould, and curing resin provided around the reinforcement (see claim 7, lines 103 and 104 and page 2, column 1, lines 57 and 58).
- 1.1. Consequently, the method according to claim 1 differs from the method according to D1 in that claim 1 comprises the steps of:
 - laying down a cored reinforcement whereas in D1 the reinforcements are fibers and
 - the reinforcement are laid by repeated passes along the channels.

The subject-matter of method claim 1 is, thus, new in the sense of Article 33(2) PCT.

- 1.2. The method step of laying down the reinforcement by repeated passes along the channels is part of the common knowledge of a skilled person. It is evident from D1 that the skilled person would lay down the reinforcement by repeated passes as a simple reinforcement is not big enough to fill even partly the channels.

However, the use of a cored reinforcement is not disclosed nor suggested in the other available prior art documents in the field of reinforced nodal structures and is not common knowledge for a skilled person.

The use of these cored reinforcements lead to a more desirable weight/strength ratio of the structure contrary to the use of fibers which would lead to a dense and heavy structure.

Consequently, it seems that the subject-matter of independent method claim 1 is new and inventive over the prior art documents (Art. 33(3) PCT).

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EXAMINATION REPORT - SEPARATE SHEET**

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2. Dependent method claims 2 to 7 concern some particular aspects of the method according to claim 1 and therefore also fulfill the requirements of Art. 33(1) PCT with respect to the available prior art documents.
3. Document GB 2 189 425 (D2), which is considered to be the closest prior art document for claim 8, discloses (applying the wording of independent claim 8) a machine for laying down reinforcement (see claim 1, line 4) for a composite moulded (see claim 1, lines 5 and 6) nodal frame structure (see claim 1, line 1) having a feeder head (see figure 1, (12)) and a mould (see claim 3 and figure 1, (1)), means for feeding (page 2, lines 36 to 42) reinforcement of constant cross-section (page 2, line 39) which causes relative movement of the feeder head and the mould (see claim 1, line 4) so that the reinforcement is laid down in and along a channel of the mould (page 2, lines 42 to 45).
 - 3.1. Consequently, the machine according to independent claim 8 differs from the device in D2 in that according to claim 8 a cored reinforcement is used whereas in D2 the reinforcement is a fiber.

The subject-matter of device claim 8 is, thus, new in the sense of Article 33(2) PCT.
 - 3.2. Moreover, the subject-matter of independent claim 8 seem inventive (Art. 33(1) PCT) for the reasons already explained in paragraph 1.2.
4. Dependent device claims 9 to 11 concern some particular aspects of the device of claim 8 and therefore also fulfill the requirements of Art. 33(1) PCT with respect to the available prior art documents.
5. Moreover, the subject-matter of claims 1 to 11 is industrially applicable in the technical field of making composite nodal structures (Article 33(4) PCT).

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Re Item VII : Certain defects in the international application.

1. Moreover, the features of the claims 1 to 11 are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
2. Claims 12 to 16 are yet not part of the application (see letter dated 28.09.01) and should not remain the application documents. Moreover the description is not adapted to the new set of claims.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference DCH/LP587080	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/GB 00/ 03279	International filing date (day/month/year) 24/08/2000	(Earliest) Priority Date (day/month/year) 24/08/1999
Applicant CRANFIELD UNIVERSITY et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 5 sheets.



It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

- a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.



the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

- b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :



contained in the international application in written form.



filed together with the international application in computer readable form.



furnished subsequently to this Authority in written form.



furnished subsequently to this Authority in computer readable form.



the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.



the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☒ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,



the text is approved as submitted by the applicant.



the text has been established by this Authority to read as follows:

REINFORCED NODAL STRUCTURE, REINFORCEMENT WITH A CORE OF EXPANSIBLE MATERIAL AND METHOD OF MOULDING AN ARTICLE

5. With regard to the **abstract**,



the text is approved as submitted by the applicant.



the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.



as suggested by the applicant.



because the applicant failed to suggest a figure.



because this figure better characterizes the invention.

9

None of the figures.

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Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-7 and 8-11

Method claim 1 discloses a method of moulding a reinforced nodal structure which includes laying down a cored reinforcement of constant cross section in and along the channels of a nodal mould and across the nodes thereof.

Device claim 8 relates to a machine for laying down reinforcement for a composite moulded nodal frame structure.

2. Claims: 12-15 and 16

Product claim 12 discloses an elongated cored reinforcement of constant cross-section for forming a composite moulded article, the reinforcement comprising an envelope of strength-giving fibres surrounding a core of expansible material.

Method claim 16 relates a method of moulding a composite article which comprises laying in a mould at least one length of a reinforcement, closing the mould to cause expansion of the reinforcement to reduce void space within and around the reinforcement, and curing resin deposited around the reinforcement.

INTERNATIONAL SEARCH REPORT

International Application No

P B 00/03279

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B29D28/00 B29C70/38 C08J9/228 B29C44/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B29D B29C A63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 1 373 344 A (SECR DEFENCE) 13 November 1974 (1974-11-13) the whole document ---	1,3-6
A	GB 2 189 425 A (CAMBRIAN PLASTICS LTD) 28 October 1987 (1987-10-28) claims 1-16; figures 1-4 ---	1,3-6
A	FR 2 250 628 A (M & M INTERNATIONAL PLASTICS) 6 June 1975 (1975-06-06) claims 1,3; figures 1,3 ---	1,3-6
A	US 4 137 354 A (MAYES JR JAMES T ET AL) 30 January 1979 (1979-01-30) figures 1,15 --- -/-	7

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

2 January 2001

Date of mailing of the international search report

12.01.01

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

Authorized officer

Foulger, C

INTERNATIONAL SEARCH REPORT

International Application No

PO 00/03279

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
X	US 4 212 461 A (CECKA ANDREW M ET AL) 15 July 1980 (1980-07-15) column 3, line 25 -column 4, line 22; claims 1-3; figure 4 ---	12-16
X	US 4 399 992 A (MOLITOR ROBERT P) 23 August 1983 (1983-08-23) column 5, line 29-38; claim 1; figures 3-6 ---	12-16
X	EP 0 270 462 A (SONOCO GUNTHER) 8 June 1988 (1988-06-08) column 3, line 10-27; figures 1-12,14-16 column 4, line 31-36; claims 1-30 ---	12,13,15
X	FR 2 462 266 A (TECH VERRE TISSE) 13 February 1981 (1981-02-13) claims 1-6; figure 1 ---	12-15
A	US 3 936 336 A (PHILLIPS LESLIE NATHAN) 3 February 1976 (1976-02-03) figure 1 -----	12,14

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/03279

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 1373344	A	13-11-1974	NONE	
GB 2189425	A	28-10-1987	NONE	
FR 2250628	A	06-06-1975	NONE	
US 4137354	A	30-01-1979	NONE	
US 4212461	A	15-07-1980	NONE	
US 4399992	A	23-08-1983	NONE	
EP 0270462	A	08-06-1988	FR 2607750 A AT 62864 T AU 612995 B AU 8213287 A BR 8706566 A DE 3769607 D DK 635987 A,B, IL 84715 A JP 1085714 A NZ 222816 A PT 86291 A,B ZA 8709134 A	10-06-1988 15-05-1991 25-07-1991 09-06-1988 12-07-1988 29-05-1991 05-06-1988 16-09-1991 30-03-1989 26-08-1992 17-01-1989 04-06-1988
FR 2462266	A	13-02-1981	NONE	
US 3936336	A	03-02-1976	GB 1305198 A	31-01-1973

For Training Office use only

International Application No.

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

International Filing Date

Name of receiving Office and "PCT" International Application:

Applicant's or agent's file reference: DCH1P5872080
 or desired file characters maximum

Box No. I	TITLE OF INVENTION MOULDED COMPOSITE PRODUCTION		
Box No. II	APPLICANT		
Name and address: <i>(family name followed by given names for a legal entity full official designation)</i> <i>The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.</i> <u>CRANFIELD UNIVERSITY</u> CRANFIELD BEDFORDSHIRE MK43 0AL GB		<input type="checkbox"/> This person is also inventor. Telephone No. Facsimile No. Teleprinter No.	
State (that is, country) of nationality: UK		State (that is, country) of residence: UK	
This person is applicant for the purposes of:			
<input type="checkbox"/> all designated States <input checked="" type="checkbox"/> all designated States except the United States of America <input type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box			
Box No. III	FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)		
Name and address: <i>(family name followed by given names for a legal entity full official designation)</i> <i>The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.</i> MELLIS ANDREW CO SCHOOL OF INDUSTRIAL AND MANUFACTURING SCIENCES CRANFIELD UNIVERSITY CRANFIELD BEDFORDSHIRE MK43 0AL GB		This person is: <input type="checkbox"/> applicant only <input checked="" type="checkbox"/> applicant and inventor <input type="checkbox"/> inventor only, <i>if this check box is marked, do not fill in below</i>	
State (that is, country) of nationality: UK		State (that is, country) of residence: UK	
This person is applicant for the purposes of:			
<input type="checkbox"/> all designated States <input type="checkbox"/> all designated States except the United States of America <input checked="" type="checkbox"/> the United States of America only <input type="checkbox"/> the States indicated in the Supplemental Box			
<input checked="" type="checkbox"/> Further applicants and/or (further) inventors are indicated on a continuation sheet			
Box No. IV	AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE		
The person identified below is hereby has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:		<input checked="" type="checkbox"/> agent <input type="checkbox"/> common representative	
Name and address: <i>(family name followed by given names for a legal entity full official designation)</i> <i>The address must include postal code and name of country.</i> HARRISON, JACQUELINE and others NEWPORT INTERNATIONAL 14 DENBIGH STREET LONDON NW2 1-6HP GBR		Telephone No.: 020 7240 4405 Facsimile No.: +44 20 7240 9339 Teleprinter No.	
<input type="checkbox"/> Mark the check box where you wish to claim priority from an earlier application filed in or outside the national territory of the State of residence of the applicant.			

Supplemental Box*If the Supplemental Box is not used, this sheet need not be included in the request***Use this box in the following cases:**

- i. *If in any of the Boxes the space is insufficient to furnish all the information, in such case write "Continuation of Box No. ..." (indicate the number of the Box) and furnish the information in the same manner as required according to the captions of the Box in which the space was insufficient, in particular:*
 - (i) *if more than two persons are involved as applicants and/or inventors and a "Continuation Sheet" is available, in such case write "Continuation of Box No. III" and indicate for each additional person the same type of information as required in Box No. III. The country of the address indicated in this Box is the applicant's State; that is, country of residence if no State of residence is indicated below;*
 - (ii) *if in Box No. II or in any of the sub-boxes of Box No. III, the indication "the States indicated in the Supplemental Box" is checked, in such case write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III", as the case may be; indicate the name of the applicant(s) involved and next to each such name, the State(s) and/or where applicable, ARIPO, Eurasian, European or OAPI patent, for the purposes of which the named person is applicant;*
 - (iii) *if in Box No. II or in any of the sub-boxes of Box No. III, the inventor or the inventor applicant is not inventor for the purposes of all designated States or for the purposes of the United States of America, in such case write "Continuation of Box No. II" or "Continuation of Box No. III" or "Continuation of Boxes No. II and No. III", as the case may be; indicate the name of the inventor(s) and next to each such name, the State(s) and/or where applicable, ARIPO, Eurasian, European or OAPI patent, for the purposes of which the named person is inventor;*
 - (iv) *if in addition to the agent(s) indicated in Box No. IV, there are further agents, in such case write "Continuation of Box No. IV" and indicate for each further agent the same type of information as required in Box No. IV;*
 - (v) *if in Box No. V, the name of any State (or OAPI) is accompanied by the indication "patent of addition" or "certificate of addition," or if in Box No. V, the name of the United States of America is accompanied by an indication "Continuation" or "Continuation-in-part", in such case, write "Continuation of Box No. V" and the name of each State involved (or OAPI), and after the name of each such State (or OAPI), the number of the parent title or parent application and the date of grant of the parent title or filing of the parent application;*
 - (vi) *if in Box No. VI, there are more than three earlier applications whose priority is claimed, in such case, write "Continuation of Box No. VI" and indicate for each additional earlier application the same type of information as required in Box No. VI;*
 - (vii) *if in Box No. VI, the earlier application is an ARIPO application; in such case, write "Continuation of Box No. VI", specify the number of the item corresponding to that earlier application and indicate at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed.*
2. *If with regard to the precautionary designation statement contained in Box No. V, the applicant wishes to exclude any State(s) from the scope of that statement; in such case, write "Designation(s) excluded from precautionary designation statement" and indicate the name or two-letter code of each state so excluded.*
3. *If the applicant claims, in respect of any designated Office, the benefits of provisions of the national law concerning non-prejudicial disclosures or exceptions to lack of novelty; in such case, write "Statement Concerning Non-Prejudicial Disclosures or Exceptions to Lack of Novelty" and furnish that statement below.*

Continuation of Box IV**Continuation of Box No. ?**

ARMITAGE, IAN M. WALTON, SEÁN M.
 BRASNETT, ADRIAN H. WATSON, ROBERT J.
 CALDERBANK, T. ROGER
 CARTER, STEPHEN
 COLEIRO, RAYMOND
 CRIPPS, JOANNA E.
 FORD, MICHAEL F.
 HACKNEY, NIGEL J.
 HARRISON, DAVID C.
 KIDDLE, SIMON J.
 KREMER, SIMON M.
 LYONS, JUNE, M.
 NICHOLLS, KATHRYN M.
 PAGET, HUGH C. E.
 SANDERSON, MICHAEL J.
 STONER, G. PATRICK
 STUART, IAN

Box No. VI		PRIORITY CLAIM		<input type="checkbox"/> Further priority claims are indicated in the Supplemental Box	
Filing date of earlier application (day/month/year)	No. of earlier application	Where application is:			
		national application country	regional application * regional Office	international application receiving Office	
item (1) 24 August 1999	99200719	GB			
item (2)					
item (3)					

☐ The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s).

* Where the earlier application is an ARIPO application, it is mandatory to indicate in the supplemental box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(iii)). See Supplemental Box.

Box No. VII INTERNATIONAL SEARCHING AUTHORITY

Choice of International Searching Authority (ISA)
(If two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):

ISA /

Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):

Date (day/month/year) Number Country (or regional Office)

Box No. VIII CHECK LIST: LANGUAGE OF FILING

This international application contains the following number of sheets		This international application is accompanied by the item(s) marked below:
request	:5	1. <input checked="" type="checkbox"/> fee calculation sheet
description (excluding sequence listing part)	:14	2. <input type="checkbox"/> separate signed power of attorney
claims	:3	3. <input type="checkbox"/> copy of general power of attorney; reference number, if any:
abstract	:1	4. <input type="checkbox"/> statement explaining lack of signature
drawings	:8	5. <input type="checkbox"/> priority document(s) identified in Box No. VI as item(s):
sequence listing part of description	:0	6. <input type="checkbox"/> translation of international application into (language):
Total number of sheets	:31	7. <input type="checkbox"/> separate indications concerning deposited microorganisms or other biological matter
		8. <input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form
		9. <input type="checkbox"/> other (specify):

Figure of the drawings which should accompany the abstract 9

Language of filing of the international application: ENGLISH

Box No. IX SIGNATURE OF APPLICANT OR AGENT

Next to each signature indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).

KREMER, SIMON M.
APPOINTED AGENT

For receiving Office use only

1. Date of actual receipt of the purported international application:	2. Drawings: <input type="checkbox"/> received <input type="checkbox"/> not received
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:	
4. Date of timely receipt of the required corrections under PCT Article 11(2):	
5. International Searching Authority (if two or more are competent): ISA/	
6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid	

For International Bureau use only

Date of receipt of the record copy by the International Bureau

PCT

FEE CALCULATION SHEET

Annex to the Request

For receiving Office use only

International application No.

Date stamp of the receiving Office

Applicant's or agent's
file reference

DCH LP5872980

Applicant

CRANFIELD UNIVERSITY

CALCULATION OF PRESCRIBED FEES

1 TRANSMITTAL FEE £55 T

2 SEARCH FEE £605 S

International search to be carried out by _____
(If two or more International Searching Authorities are competent in relation to the international application, indicate the name of the Authority which is chosen to carry out the international search.)

3. INTERNATIONAL FEE

Basic FeeThe international application contains 31 sheets.first 30 sheets £264 b₁1 x £6 = £6 b₂

remaining sheets additional amount

Add amounts entered at b₁ and b₂ and enter total at B.... £270 B**Designation Fees**The international application contains 8 designations.8 x £56 = £448 Dnumber of designation fees amount of designation fee
payable (maximum \$)

Add amounts entered at B and D and enter total at I..... £718 I

(Applicants from certain States are entitled to a reduction of 75% of the international fee. Where the applicant is (or all applicants are) so entitled, the total to be entered at I is 25% of the sum of the amounts entered at B and D.)

4. FEE FOR PRIORITY DOCUMENT (if applicable) £0 P

5. TOTAL FEES PAYABLE

Add amounts entered at T, S, I and P, and enter total in the TOTAL box

£1378

TOTAL

☐ The designation fees are not paid at this time.**MODE OF PAYMENT**☐ authorization to charge
deposit account (see below)☐ bank draft☐ coupons☒ cheque☐ cash☐ other (specify)☐ postal money order☐ revenue stamps**DEPOSIT ACCOUNT AUTHORIZATION** (this mode of payment may not be available at all receiving Offices)The RO ☐ is hereby authorized to charge the total fee indicated above to my deposit account☐ is hereby authorized to charge any deficiency or credit any overpayment in the total fees indicated above to my deposit account☐ is hereby authorized to charge the fee for preparation and transmittal of the priority document to the International Bureau of WIPO to my deposit accountDeposit Account Number _____ Day day month year

Signature _____

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 00/03279

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 B29D28/00 B29C70/38 C08J9/228 B29C44/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B29D B29C A63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 1 373 344 A (SECR DEFENCE) 13 November 1974 (1974-11-13) the whole document ---	1,3-6
A	GB 2 189 425 A (CAMBRIAN PLASTICS LTD) 28 October 1987 (1987-10-28) claims 1-16; figures 1-4 ---	1,3-6
A	FR 2 250 628 A (M & M INTERNATIONAL PLASTICS) 6 June 1975 (1975-06-06) claims 1,3; figures 1,3 ---	1,3-6
A	US 4 137 354 A (MAYES JR JAMES T ET AL) 30 January 1979 (1979-01-30) figures 1,15 --- -/--	7

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

Y document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

* & * document member of the same patent family

Date of the actual completion of the international search

2 January 2001

Date of making of the international search report

12.01.01

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2230 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl
 Fax: (+31-70) 340-3016

Authorized officer:

Foulger, C

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/03279

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 212 461 A (CECKA ANDREW M ET AL) 15 July 1980 (1980-07-15) column 3, line 25 -column 4, line 22; claims 1-3; figure 4 ---	12-16
X	US 4 399 992 A (MOLITOR ROBERT P) 23 August 1983 (1983-08-23) column 5, line 29-38; claim 1; figures 3-6 ---	12-16
X	EP 0 270 462 A (SONOCO GUNTHER) 8 June 1988 (1988-06-08) column 3, line 10-27; figures 1-12,14-16 column 4, line 31-36; claims 1-30 ---	12,13,15
X	FR 2 462 266 A (TECH VERRE TISSE) 13 February 1981 (1981-02-13) claims 1-6; figure 1 ---	12-15
A	US 3 936 336 A (PHILLIPS LESLIE NATHAN) 3 February 1976 (1976-02-03) figure 1 -----	12,14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 00/03279

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-7 and 8-11

Method claim 1 discloses a method of moulding a reinforced nodal structure which includes laying down a cored reinforcement of constant cross section in and along the channels of a nodal mould and across the nodes thereof.

Device claim 8 relates to a machine for laying down reinforcement for a composite moulded nodal frame structure.

2. Claims: 12-15 and 16

Product claim 12 discloses an elongated cored reinforcement of constant cross-section for forming a composite moulded article, the reinforcement comprising an envelope of strength-giving fibres surrounding a core of expansible material.

Method claim 16 relates a method of moulding a composite article which comprises laying in a mould at least one length of a reinforcement, closing the mould to cause expansion of the reinforcement to reduce void space within and around the reinforcement, and curing resin deposited around the reinforcement.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/03279

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 1373344	A	13-11-1974	NONE	
GB 2189425	A	28-10-1987	NONE	
FR 2250628	A	06-06-1975	NONE	
US 4137354	A	30-01-1979	NONE	
US 4212461	A	15-07-1980	NONE	
US 4399992	A	23-08-1983	NONE	
EP 0270462	A	08-06-1988	FR 2607750 A	10-06-1988
			AT 62864 T	15-05-1991
			AU 612995 B	25-07-1991
			AU 8213287 A	09-06-1988
			BR 8706566 A	12-07-1988
			DE 3769607 D	29-05-1991
			DK 635987 A,B,	05-06-1988
			IL 84715 A	16-09-1991
			JP 1085714 A	30-03-1989
			NZ 222816 A	26-08-1992
			PT 86291 A,B	17-01-1989
			ZA 8709134 A	04-06-1988
FR 2462266	A	13-02-1981	NONE	
US 3936336	A	03-02-1976	GB 1305198 A	31-01-1973

PCT JT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING
OF A CHANGE(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

HARRISON, David, C.
Mewburn Ellis
York House
23 Kingsway
London WC2B 6HP
ROYAUME-UNI

Date of mailing (day/month/year) 21 February 2002 (21.02.02)	IMPORTANT NOTIFICATION
Applicant's or agent's file reference DCH/LP587080	
International application No. PCT/GB00/03279	International filing date (day/month/year) 24 August 2000 (24.08.00)

1. The following indications appeared on record concerning: <input checked="" type="checkbox"/> the applicant <input type="checkbox"/> the inventor <input type="checkbox"/> the agent <input type="checkbox"/> the common representative		
Name and Address CRANFIELD UNIVERSITY Cranfield Bedfordshire MK43 0AL United Kingdom	State of Nationality GB	State of Residence GB
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	
2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning: <input checked="" type="checkbox"/> the person <input type="checkbox"/> the name <input type="checkbox"/> the address <input type="checkbox"/> the nationality <input type="checkbox"/> the residence		
Name and Address CORETEX STRUCTURES LIMITED Turing House 1 Southbridge Grove Kents Hill Milton Keynes MK7 6HW United Kingdom	State of Nationality GB	State of Residence GB
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	
3. Further observations, if necessary: Assignment		
4. A copy of this notification has been sent to: <input checked="" type="checkbox"/> the receiving Office <input type="checkbox"/> the designated Offices concerned <input type="checkbox"/> the International Searching Authority <input checked="" type="checkbox"/> the elected Offices concerned <input type="checkbox"/> the International Preliminary Examining Authority <input type="checkbox"/> other:		

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Y. KUWAHARA Telephone No.: (41-22) 338.83.38
--	--

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/03279

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1-14 as originally filed

Claims, No.:

1-11 as originally filed

Drawings, sheets:

1/8-8/8 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).
3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:
- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.
4. The amendments have resulted in the cancellation of:

- ☐ the description. pages:
- ☐ the claims. Nos.:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/GB00/03279

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-11
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-11
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-11
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03279

**Re Item V : Reasoned statement under Article 35(2) with regard to novelty,
inventive step or industrial applicability.**

1. Document US 1 373 344 (D1), that is considered to be the closest prior art document for claim 1, discloses (applying the wording of present claim 1) a method of moulding a reinforced nodal structure (see column 1, line 12) which includes laying down a reinforcement of constant cross section (see column 2, line 75) in and along the channels (see column 2, lines 70 to 72 and figure 1 and claim 7, line 103) of a nodal mould (see figure 2) and across the nodes thereof to at least partially fill the channels (see claim 7, lines 103 and 104), closing the mould, and curing resin provided around the reinforcement (see claim 7, lines 103 and 104 and page 2, column 1, lines 57 and 58).
- 1.1. Consequently, the method according to claim 1 differs from the method according to D1 in that claim 1 comprises the steps of:
 - laying down a cored reinforcement whereas in D1 the reinforcements are fibers and
 - the reinforcement are laid by repeated passes along the channels.

The subject-matter of method claim 1 is, thus, new in the sense of Article 33(2) PCT.

- 1.2. The method step of laying down the reinforcement by repeated passes along the channels is part of the common knowledge of a skilled person. It is evident from D1 that the skilled person would lay down the reinforcement by repeated passes as a simple reinforcement is not big enough to fill even partly the channels.

However, the use of a cored reinforcement is not disclosed nor suggested in the other available prior art documents in the field of reinforced nodal structures and is not common knowledge for a skilled person.

The use of these cored reinforcements lead to a more desirable weight/strength ratio of the structure contrary to the use of fibers which would lead to a dense and heavy structure.

Consequently, it seems that the subject-matter of independent method claim 1 is new and inventive over the prior art documents (Art. 33(3) PCT).

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03279

2. Dependent method claims 2 to 7 concern some particular aspects of the method according to claim 1 and therefore also fulfill the requirements of Art. 33(1) PCT with respect to the available prior art documents.
3. Document GB 2 189 425 (D2), which is considered to be the closest prior art document for claim 8, discloses (applying the wording of independent claim 8) a machine for laying down reinforcement (see claim 1, line 4) for a composite moulded (see claim 1, lines 5 and 6) nodal frame structure (see claim 1, line 1) having a feeder head (see figure 1, (12)) and a mould (see claim 3 and figure 1, (1)), means for feeding (page 2, lines 36 to 42) reinforcement of constant cross-section (page 2, line 39) which causes relative movement of the feeder head and the mould (see claim 1, line 4) so that the reinforcement is laid down in and along a channel of the mould (page 2, lines 42 to 45).
 - 3.1. Consequently, the machine according to independent claim 8 differs from the device in D2 in that according to claim 8 a cored reinforcement is used whereas in D2 the reinforcement is a fiber.

The subject-matter of device claim 8 is, thus, new in the sense of Article 33(2) PCT.
 - 3.2. Moreover, the subject-matter of independent claim 8 seem inventive (Art. 33(1) PCT) for the reasons already explained in paragraph 1.2.
4. Dependent device claims 9 to 11 concern some particular aspects of the device of claim 8 and therefore also fulfill the requirements of Art. 33(1) PCT with respect to the available prior art documents.
5. Moreover, the subject-matter of claims 1 to 11 is industrially applicable in the technical field of making composite nodal structures (Article 33(4) PCT).

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/GB00/03279

Re Item VII : Certain defects in the international application.

1. Moreover, the features of the claims 1 to 11 are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).
2. Claims 12 to 16 are yet not part of the application (see letter dated 28.09.01) and should not remain the application documents. Moreover the description is not adapted to the new set of claims.

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
1 March 2001 (01.03.2001)

PCT

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WO 01/14128 A1

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9920071.9 24 August 1999 (24.08.1999) GB

(71) Applicant (for all designated States except US): **CRANFIELD UNIVERSITY** [GB/GB]; Cranfield, Bedfordshire MK43 0AL (GB).

(72) Inventors: and

(75) Inventors/Applicants (for US only): **MILLS, Andrew** [GB/GB]; School of Industrial and Manufacturing Sciences, Cranfield University, Cranfield, Bedfordshire MK43 0AL (GB). **COUSINS, Steven** [GB/GB]; School of

Industrial and Manufacturing Sciences, Cranfield University, Cranfield, Bedfordshire MK43 0AL (GB). **BATEUP, Lee** [GB/GB]; School of Industrial and Manufacturing Sciences, Cranfield University, Cranfield, Bedfordshire MK43 0AL (GB). **BACKHOUSE, Robert** [GB/GB]; School of Industrial and Manufacturing Sciences, Cranfield University, Cranfield, Bedfordshire MK43 0AL (GB).

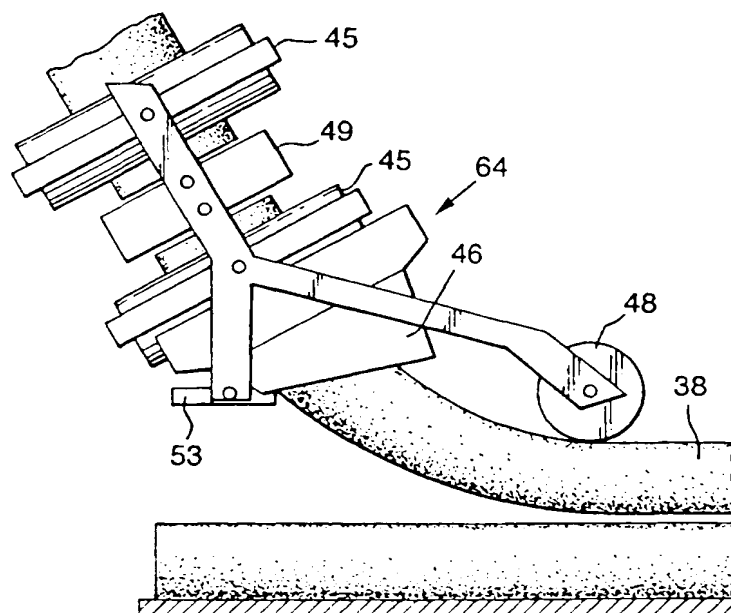
(74) Agents: **HARRISON, David, C.** et al.; Mewburn Ellis, York House, 23 Kingsway, London WC2B 6HP (GB).

(81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,

[Continued on next page]

(54) Title: REINFORCED NODAL STRUCTURE, REINFORCEMENT WITH A CORE OF EXPANSIBLE MATERIAL AND METHOD OF MOULDING AN ARTICLE



(57) Abstract: A machine and method for moulding a composite of complex nodal structure includes laying down under CNC a reinforcement (38) of constant cross-section repeatedly into and along channels (26) of a mould (24) and through nodes of the structure, closing the mould, impregnating it with resin and curing the resin.

WO 01/14128 A1



IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

- With international search report.
- Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.

REINFORCED NODAL STRUCTURE, REINFORCEMENT WITH A CORE OF EXPANSIBLE MATERIAL
AND METHOD OF MOULDING AN ARTICLE

The present invention relates to an apparatus for and method of producing a composite structure and relates particularly, but not exclusively, to the production of vehicle structures and the like. The present invention also relates to a cored reinforcement suitable for making a composite structure.

It is known to produce a composite structure by laying a plurality of fibres onto a first portion of a mould having a desired shape and introducing a resin material either during the laying up process or thereafter in order to ensure the fibres are bonded to each other and produce a component of the desired shape.

It is also known to employ a mould having inner and outer portions which, upon assembly, are used to define the external shape of the component to be moulded.

Additionally, it is also known to employ an injection technique in which resin is injected or drawn into the mould cavity during the manufacturing process. This injection step facilitates the impregnation of resin material between the fibrous structure and fills the mould cavity thereby to define accurately the final shape of the desired product.

Whilst the above processes provide a perfectly adequate method of manufacturing a composite component it does not lend itself readily to the production of complicated three-dimensional structures. Additionally, some structures can be somewhat bulkier than might be desired, as producing strong and slim corners and joints can be problematic.

A particular problem is met in moulding complex,

multi-noded, frame structures such as vehicle frames. Although it is theoretically possible to use the prior art hand lay-up procedures for these costs would be prohibitive; and, again in the context of vehicle frames, crash-resistance and rigidity in the cage formed by the frame for at least the passenger-carrying part of the vehicle, require great care and control in the formation of the joints at the nodes and in how reinforcement is continued through a node to confer coherence and strength.

Furthermore, use of fibres only as reinforcement will lead to a dense and heavy structure. It is known that the reinforcement can take the form of a carbon-fibre-bound foam core of constant cross-section which is of indefinite length and can therefore be fed onto the mould as desired. This gives a more desirable weight/strength ratio. However, there may still be substantial voids between such reinforcement which become filled with resin, and the desired weight to strength ratio may not be reached.

It is an object of the present invention to provide a machine and process for producing a composite structure which lends itself to the moulding of complicated three-dimensional structures.

Accordingly a first aspect of the present invention provides a machine for laying up moulded resin-based structural composite, wherein the composite is a nodal frame, which includes a feed head for cored reinforcement of constant cross-section, means for controlling the feed of the composite from the head and for severing the composite into fed lengths, and means for causing coordinated relative movement between the head and a

nodal mould whereby to feed lengths of reinforcement into and along the open mould and through the nodes thereof.

The feeding and coordination will be under CNC (computer numerical control).

5 The cross-sectional shape of the cored reinforcement need have no relation to the shape of the mould.

 The feeding is preferably repeated until the mould is at least filled throughout with the lengths of reinforcement; preferably it is somewhat overfilled so
10 that closure of the mould causes compression of the reinforcement. However, it is not excluded that the mould may be underfilled with the lengths of reinforcement.

15 In a second aspect of the invention a moulding process for making a nodal frame of composite includes providing a length of cored reinforcement of constant cross-section, repeatedly feeding that reinforcement into and along an open nodal mould for the frame through the
20 nodes thereof, severing the length with shorter lengths as necessary to fill the mould, closing the mould, and curing resin provided around the reinforcement.

 The process may include overfilling the open mould, whereby closing the mould compresses the reinforcement.
25 Again, the cross-sectional shape of the reinforcement need have no relation to the shape of the mould.

 Another object of the present invention is to reduce the mass of a composite moulded structure or
30 article.

 Accordingly in a third aspect of the invention we use as a reinforcement a cored reinforcement with an

envelope of strength-giving fibres - most preferably carbon fibres - surrounding a core of expansible (preferably closed cell foam) material. The core is expansible under reduced pressure applied to a closed mould (e.g. to draw resin into the mould) and therefore the finished article contains hardly any or ideally no voids between reinforcements to be occupied by resin; and instead the resin is found exclusively impregnating and encapsulating the strength-giving fibrous structure.

The invention in a fourth aspect therefore provides a method of moulding the composite article which consists of laying in a mould at least one length of reinforcement of constant cross-section (which constant cross-section need have no relation to the shape of the mould), the reinforcement having a core of an expansible (preferably closed cell foam) material, closing the mould, reducing the pressure in the closed mould whereby to cause expansion of the reinforcement to minimise void space within and around the reinforcement, curing resin provided around the reinforcement, and removing the mould. Preferably the strength-giving fibre is carbon fibre. The curing which will be under elevated temperature may have the effect of destroying or partially destroying the foam core.

The result is a cellular structure wherein cured resin encapsulates the reinforcing fibres in such a way as to give a favourable mass to strength ratio because the resin tends to be of higher density than the fibre or, of course, the foam core.

A preferable means and method for laying down the reinforcement in this way, preferably in numerous passes over a nodal mould, are provided by the first and second

aspects of the present invention.

The strength-giving fibre envelope may be prepared in any form suitable for the purpose. Particularly suitable is a braided structure. For the expansion
5 characteristic of this process, the braiding need not be symmetrical.

In the second or fourth aspect of the invention the resin may be provided by passing it into the mould (e.g. by injection, or by evacuation to draw the resin into the
10 mould) when the mould is closed. Alternatively the resin may be introduced into the mould as the reinforcement is fed into mould. For example, the resin may be fed into the mould as a powder as the reinforcement is fed into the mould. The powder may then be fused (e.g. by a
15 travelling heater) to prevent it from escaping and/or to tack the reinforcement together.

The present invention will now be more particularly described by way of example only with reference to the accompanying drawings in which:

20 Figure 1 is an isometric projection of a vehicle substructure which might be produced in accordance with the method and apparatus of the present invention;

Figure 2 is a diagrammatic representation of a mould structure;

25 Figures 3A and 3B illustrate one possible joint arrangement between segments of the mould structure in top and side view respectively, in an open position;

Figures 4A and 4B illustrate the arrangement of Figures 3A and 3B in closed position;

30 Figure 5 illustrates an encapsulation step with introduction of resin into the interior of the mould structure;

Figure 6 illustrates a node within the composite structure;

Figures 7 and 8 illustrate in side view a machine suitable for laying down reinforcement into a mould structure;

Figure 9 is a front view of a feeder head of the machine;

Figure 10 is a side view of the feeder head of the machine;

Figures 11-18 illustrate various steps involved in the manufacture of a moulded structure in accordance with the present invention;

Figures 19-21 are lateral sections through a mould showing successive stages of loading;

Figure 22 is the same after impregnation and cure; and

Figure 23 is a perspective view and section of a composite prepared according to the process.

Referring now to the drawings in general, but particularly to Figure 1 it will be appreciated that a composite structure such as a vehicle space frame 10 is complex and not easily manufactured. The structure comprises a number of frame members 12 meeting at nodes 13 and may include subassemblies such as crush subsection 14, and components such as a rear strengthening member illustrated generally at 15. Additionally, features such as hinge, bumper or suspension member mounting points may be provided at other positions on the structure.

If the frame structure is to be made integral a collapsible internal mould part to be described will have to be used; however if the frame structure is made in two mirror image parts ie divided along its median

plane) a conventional three-dimensional mould may be used. In the latter case the joining together of the separately made halves by adding further layers over the joint can easily be achieved and be very satisfactory.

5 A simplified form of a collapsible mould structure suitable for creating an integral composite structure of Figure 1 is shown in Figure 2. From Figure 2 it will be appreciated that the mould structure comprises a plurality of linked female mould segments 24 each of
10 which has a channel portion 26 into which the reinforcement is laid during the assembly process described in detail later herein. In an erected position the mould segments 24 act to define the shape of the desired article whilst in a second, collapsed position,
15 they act to allow removal of the moulded article therefrom. In order to facilitate movement between these positions the segments are joined by a reinforced silicone rubber bag 28 which may be inflated by introducing pressurised air or any other suitable fluid
20 through inlet 30, thereby causing the bag to inflate and move the segments 24 to their assembled position. Collapse of the mould segments is achieved by withdrawing the air or other fluid from the bag either by simply releasing it therefrom or by positively withdrawing it.
25 Of course, the shape of the mould here, a simple ovoid, does not correspond with a shape needed for the frame 10; it is given by way of illustration only.

Referring now more particularly to Figures 3 and 4, the segments 24 are jointed together by means of hinge means shown generally at 32. In the particular example
30 the hinge means comprises a flexible web member having a first portion 32a fixedly attached to first segment

portion 24a and second portion 32b fixedly attached to an adjacent segment portion 24b. The flexible web portion 32 locates each segment 24 relative to its neighbour whilst providing sufficient flexibility for the segments to move between their two positions. In a simplified arrangement the hinge means may comprise a flexible material which forms the pressurising bag 28. Also shown in Figures 3 and 4 are locating means in the form of, for example, tapered pins 34 and associated holes 36 provided on adjacent flange portions 38a, 38b of adjacent mould segments 24a, 24b. Operation of the pressurising means 28 will cause the hinged segments to be moved into interlocking relationship with each other in view of the fact that the pressurising force will be applied in the direction of arrows F of Figures 3 and 4. The force causes the segments to hinge relative to each other into their closed position and ensures the security of the hinged joint.

The segments 24, once erected, act to define a mould structure onto which the composite material may be laid down, as will be described later.

Closure and injection steps are illustrated by reference to Figure 5 from which it will be appreciated that a second part 40 of the mould is brought in to enclose the laid down material 38 and is then secured in position by any suitable means. It will be appreciated that whilst Figure 5 illustrates a total encapsulation type arrangement one need only actually enclose the portions containing the laid down material and, consequently, the mould part 40 need not provide a total enclosure. In order to facilitate the rapid assembly of the tooling one might employ pneumatic or robotic

actuation systems (not shown) which move the second portion or portions 40 of the mould into position and retain them there during the subsequent steps. The act of introducing the second portion 40 preferably causes the reinforcement to be compressed and ensures the fibre structure and any inserts in it are kept still during the subsequent impregnation step. The second portion 40 of the mould is preferably coated with a silicone layer to aid sealing during infusion and release once the component has been cured. By applying a vacuum to the interior of the mould via outlet 41 one can draw resin material from reservoir 42 into the interior of the mould and cause it to pass along the strands of the fibre of the reinforcement via resin inlet 43, thereby passing between and coating the fibre with the resin, which also acts to define the outer surface of the finished article in view of the fact that it contacts the surface of the mould structure itself. The use of a vacuum step is preferred over that of a resin injection step under positive pressure as the vacuum makes the job of sealing significantly easier and reduces loads on the tooling associated with the mould process. Whilst not absolutely necessary, it will be appreciated that a small additionally internal pressure may be applied to the pressurising means 28 to help ensure that the segments 24 seal against the second portion of the mould.

Once the resin is injected, the resin is cured at elevated temperature and the second portion 40 of the mould is removed and the pressurising means deflated for the extraction of the completed space frame such as 10. Any mould debris is removed from the space frame and the tooling is then cleaned and prepared to re-use once

again. Of course, if the frame is made in halves, the mould channels 26 may be on a permanent, rigid, mould half.

Referring now to Figure 6, it will be appreciated that nodes 13 may be produced by introducing diverting inserts in the form of sections 44 thereby to divert a portion of the reinforcement around the corner created by said section so that the lengths of reinforcement pass from one frame part 12 to another continuously through the node 13.

Figure 7 illustrates in a very simplified form a machine suitable for laying reinforcement onto the mould structure. The machine 60 comprises a support frame 62 having a reinforcement supply head 64, to be described in more detail later, mounted onto a two-axis positioning head 66. The head 66 is mounted on and translatable - arrow X - along bridging member 68 which is, itself, translatable - arrow Y - along frame 62 so as to move in two dimensions. An ovoid mould structure formed of segments 24 is mounted for rotation about a longitudinal axis 63 of the frame 62 such that, on controlled translation of the feed head 64 and rotation of the mould structure it is possible to deposit the reinforcement into the channel 26 of the mould by laying it on and along that channel. This Figure also illustrates the crossover or inter meshing relationship at nodes 13 of the frame thereby to increase the rigidity of the finished frame. A programmable CNC 70 is provided to control the movement of the support frame 62 and feed head 64.

Control of the coordination of the movement of the mould and the feeder head so as to achieve laying-down of

reinforcement in the channels will normally be by the CNC, programmed for the particular frame, ie the particular mould being used: CNC will also determine the rate of feed of reinforcement from the head and if
5 discrete lengths of it are to be placed, for example through a node or at a zone where particularly high stress is expected.

Figure 8 shows a second such machine 60', with a feeder head 64 to which reinforcement comes from a roll
10 65 carried with the head (in other embodiments, however, the roll may be immobile or independently movable). As before, the head 64 can execute longitudinal or lateral movements over a mould structure, here generally 67 mounted for rotation on axis 63. Under the control of a
15 CNC 70, reinforcement can be laid down either continuously or in discrete lengths along the grooves of the mould structure until these are full or slightly overfull.

Both Figures 7 and 8 have dealt with a fully
20 rotatable mould structure; it is clear however that the mould structure may be stationary, with the feeder head adapted under CNC to move additionally in a Z axis orthogonal to the X and Y arrows, and/or can partially rotate (reciprocate). This will be the case, usually,
25 when the frame to be formed by the machine and process is such as not to require a collapsible mould structure.

Figures 9 and 10 shows the feeder head 64. Reinforcement 38 from the roll 65 or other source is taken by driven feed rollers 45 at a required rate
30 through nozzle 46 with guide wings 47. Reinforcement issuing from the nozzle is pressed into the base of channel 26, or on to a preceding layer of reinforcement,

by pressure roller 28. Cutter 49, which like feed rollers 45 is under CNC control, can operate to sever discrete lengths of reinforcements.

The reinforcement 38 comprises carbon fibre filament 50 surrounding a central core 52 which, in a preferred arrangement, comprises a compressible core such as a foam material. As described later, in respect of Figures 19-23, the reinforcement in a particularly preferred arrangement has an expansible closed cell foam core. It will, however, be appreciated that flexible or non-compressible cores may be used to advantage.

Powdered fusible binder is carried on or in the carbon fibre cover 50. A pulsed infrared heater 53 fuses binder on the surface of any preceding layer of reinforcement to tack the newly applied layer in place under closure of the mould and impregnation, as will be described with reference to Figures 11-18. Whilst the majority of the reinforcement is wound continuously it will be appreciated that this winding process may be stopped and then recommenced at any position of the mould structure such that localised areas may be provided with additional composite material in order to improve the strength of that portion. In addition to the deposition of discrete lengths of reinforcement it is possible to incorporate additional fabric, foam and metal inserts into the wound structure as the reinforcement is supplied thereto (such inserts can also, however, be added when winding is complete). Such additions serve to enable the structure to withstand large or localised loads during use and/or provide mounting points for components which must be mounted to the basic mould structure. As showed in Figures 11-18, the mould structure is filled with the

feedstock from feeder head 64 (here shown as delivering a plurality of reinforcements at one pass) whilst at the same time introducing any additional inserts (shown generally at 46) and the mould is then overfilled by a small amount (Figure 14) so that when the mould is closed by second mould part 40' (Figures 15 and 16) the reinforcement is compressed. Resin is then fed in, preferably by vacuum impregnation (Figure 17), to impregnate the voids, and is cured. The mould parts 24, 40' are removed leaving the formed frame member 12.

Figure 19 shows the channel 101 of a mould part 102 being loaded by a feeder head 103 (such as the one described above in respect of Figures 9 and 10) with successive layers of constant cross-section reinforcement 104. The reinforcement here is shown as rectangular cross-section; this is diagrammatic and normally it would be circular or oval in cross-section, with an comparatively soft, expansible, closed cell plastics material foam core enwrapped by an envelope of strength-giving fibres. Particularly suitable for such fibres are carbon fibres and they may be arranged in a braid around the core.

The reinforcement is fed in until the channel is sufficiently full, then as seen in Figure 20 a second part 105 of the mould is placed on and sealed to it. In Figure 21, reduced pressure is applied to the mould to draw resin into it. The resin cannot permeate the closed cell foam core and is instead drawn along the channels formed by the fibre covers of the various lengths of reinforcement. At the same time, the reduced pressure causes an expansion of the foam cores so that the voids between the reinforcements are substantially or even

entirely eliminated, leaving only a comparatively thin network or honeycomb 106 of walls of reinforcing fibre impregnated with resin. This is shown schematically in Figure 22 where the presence of a resin is indicated by thickened honeycomb lines 107. In the process of curing, which is at an elevated temperature, the foam core of the reinforcement may be partially or even completely destroyed or melted but this is of no importance. What is left, as seen in Figure 23, is a honeycomb rigid-walled complete beam structure 108 of very satisfactory strength to weight ratio. Voids where the foam has been destroyed are seen in the darkened areas such as 109.

This construction and type of reinforcement can be used in complex nodal structures, as described above in respect of Figures 1-18, with the reinforcement being taken through the nodes so as to form an integral structure not requiring the making of joints.

CLAIMS

1. A method of moulding a reinforced nodal structure which includes laying down a cored reinforcement of constant cross section in and along the channels of a nodal mould and across the nodes thereof by repeated passes along the channels to at least partially fill the channels, closing the mould, and curing resin provided around the reinforcement.

2. A method according to claim 1 wherein the reinforcement is a foam-cored carbon fibre structure.

3. A method according to claim 1 or claim 2 wherein the channels are overfilled whereby closing the mould compresses the reinforcement.

4. A method according to any one of the previous claims wherein the laying down involves relative movement of a feeder head and the mould and control of the feed of reinforcement, all under computer numerical control (CNC).

5. A method according to claim 4 which includes also severing lengths of the reinforcement in the feeder head under CNC.

6. A method according to any one of the preceding claims which includes thermally tacking reinforcement to a preceding layer of reinforcement.

7. A method according to any one of the preceding

claims which includes introducing at least one insert in the mould to divert locally the reinforcement, to provide localised strengthening and/or to provide a mounting point.

5

8. A machine for laying down reinforcement for a composite moulded nodal frame structure having a feeder head and a mould, means for feeding cored reinforcement of constant cross-section through the feeder head which causes relative movement of the feeder head and the mould so that the reinforcement is laid down in and along a channel of the mould.

9. A machine according to claim 8 wherein the feeder head additionally includes means for severing the reinforcement into lengths.

10. A machine according to claim 8 or claim 9 which is under CNC.

20

11. A machine according to claim 8, claim 9 or claim 10 wherein the feeder head includes also a radiant heater.

12. An elongate cored reinforcement of constant cross-section for forming a composite moulded article, the reinforcement comprising an envelope of strength giving fibres surrounding a core of expansible material.

13. A cored reinforcement according to claim 12, in which the fibres are carbon fibres

14. A cored reinforcement according to claim 12 or

claim 13, in which the envelope of strength-giving fibres has a braided structure.

15. A cored reinforcement according to claim 12, claim
5 13 or claim 14, in which the expansible material is a closed cell foam material.

16. A method of moulding a composite article which
comprises laying in a mould at least one length of the
10 reinforcement of one of claims 12 to 15, closing the mould, reducing the pressure in the mould to cause expansion of the reinforcement to reduce void space within and around the reinforcement, and curing resin deposited around the reinforcement.

15

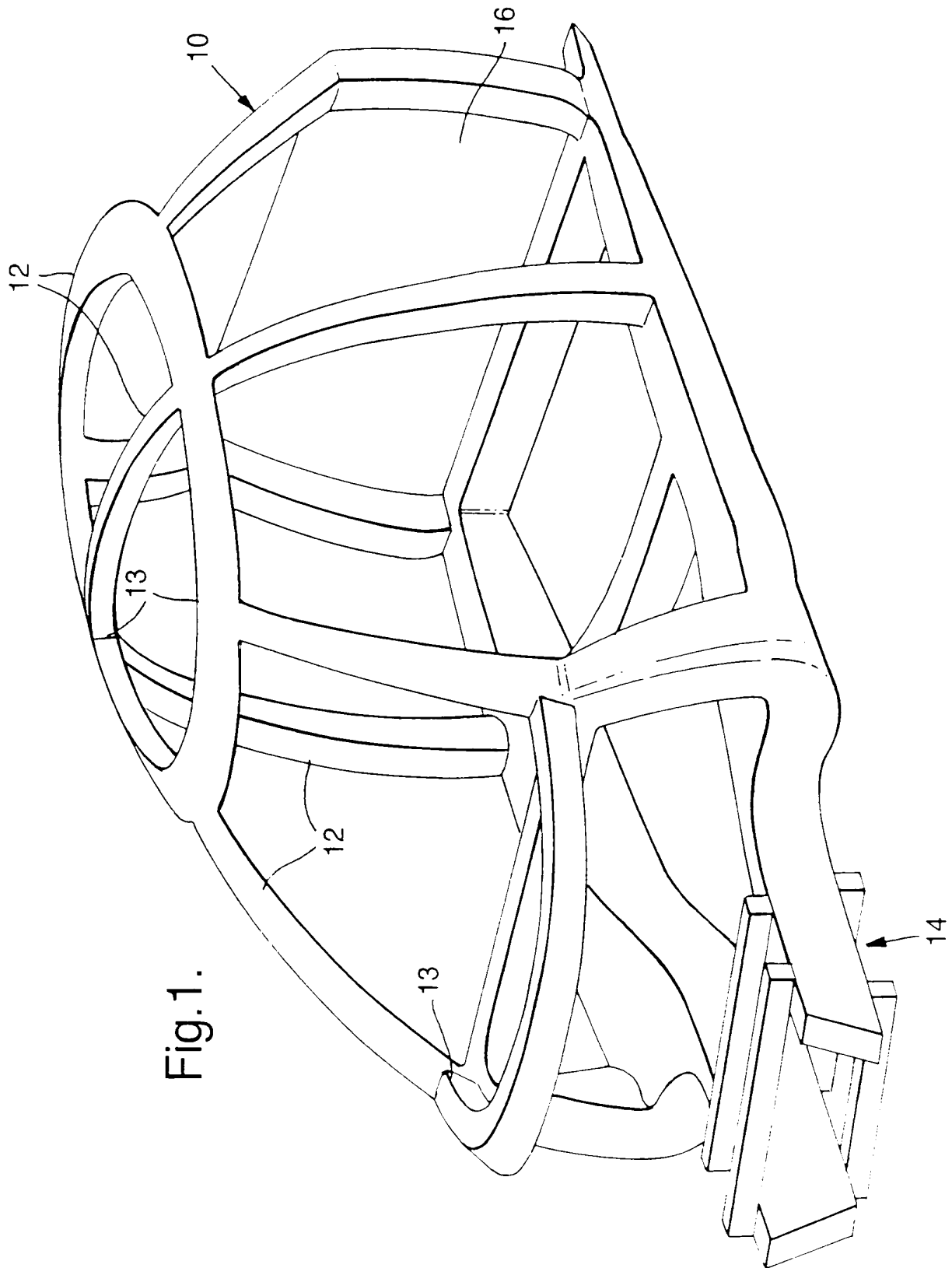


Fig.2.

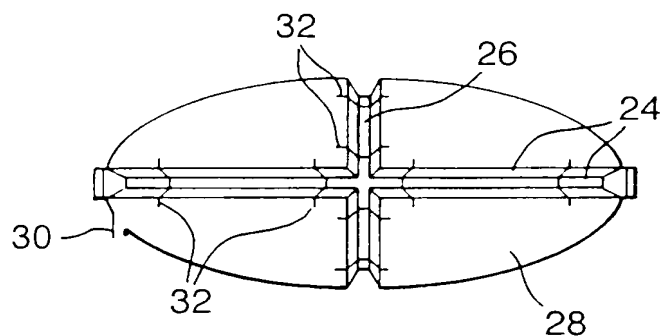


Fig.3A.

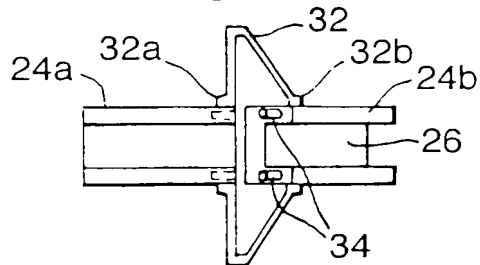


Fig.4A.

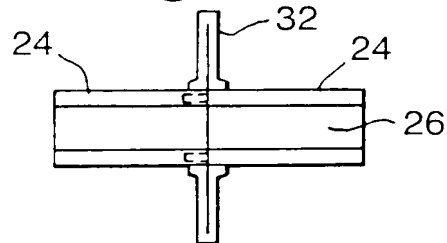


Fig.3B.

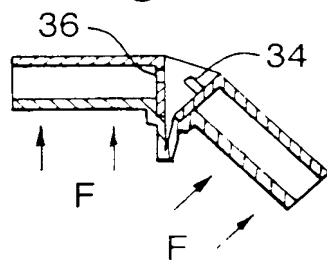


Fig.4B.

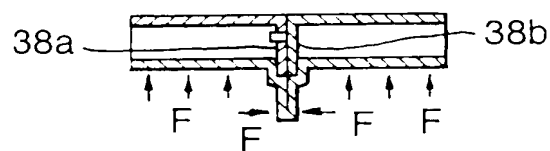


Fig.5.

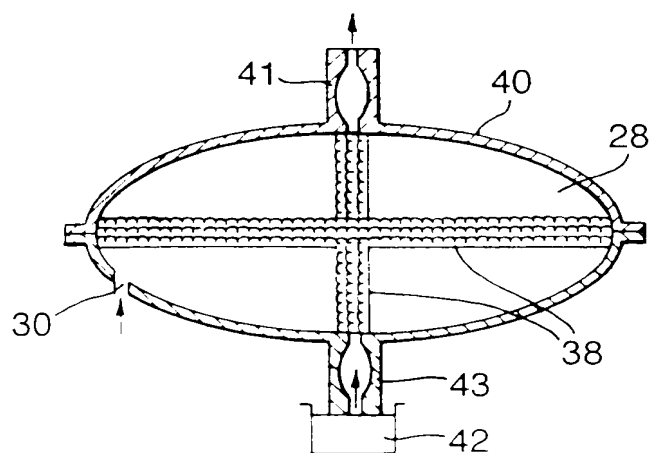


Fig.6.

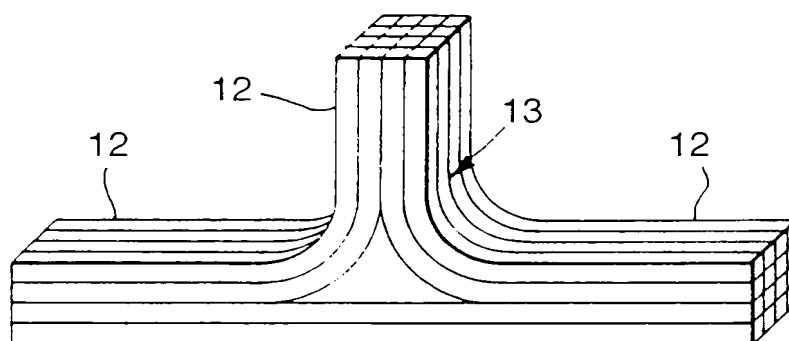
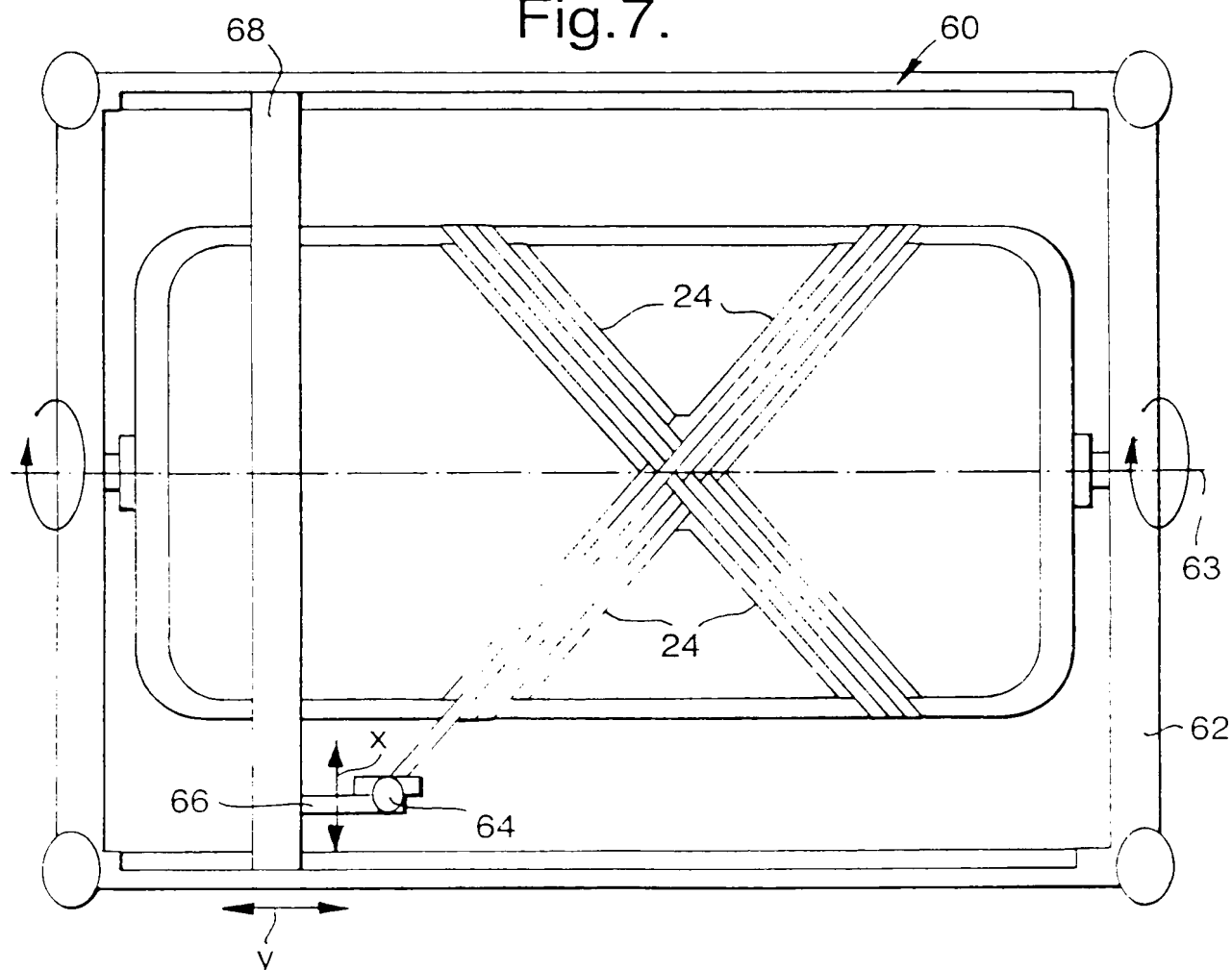
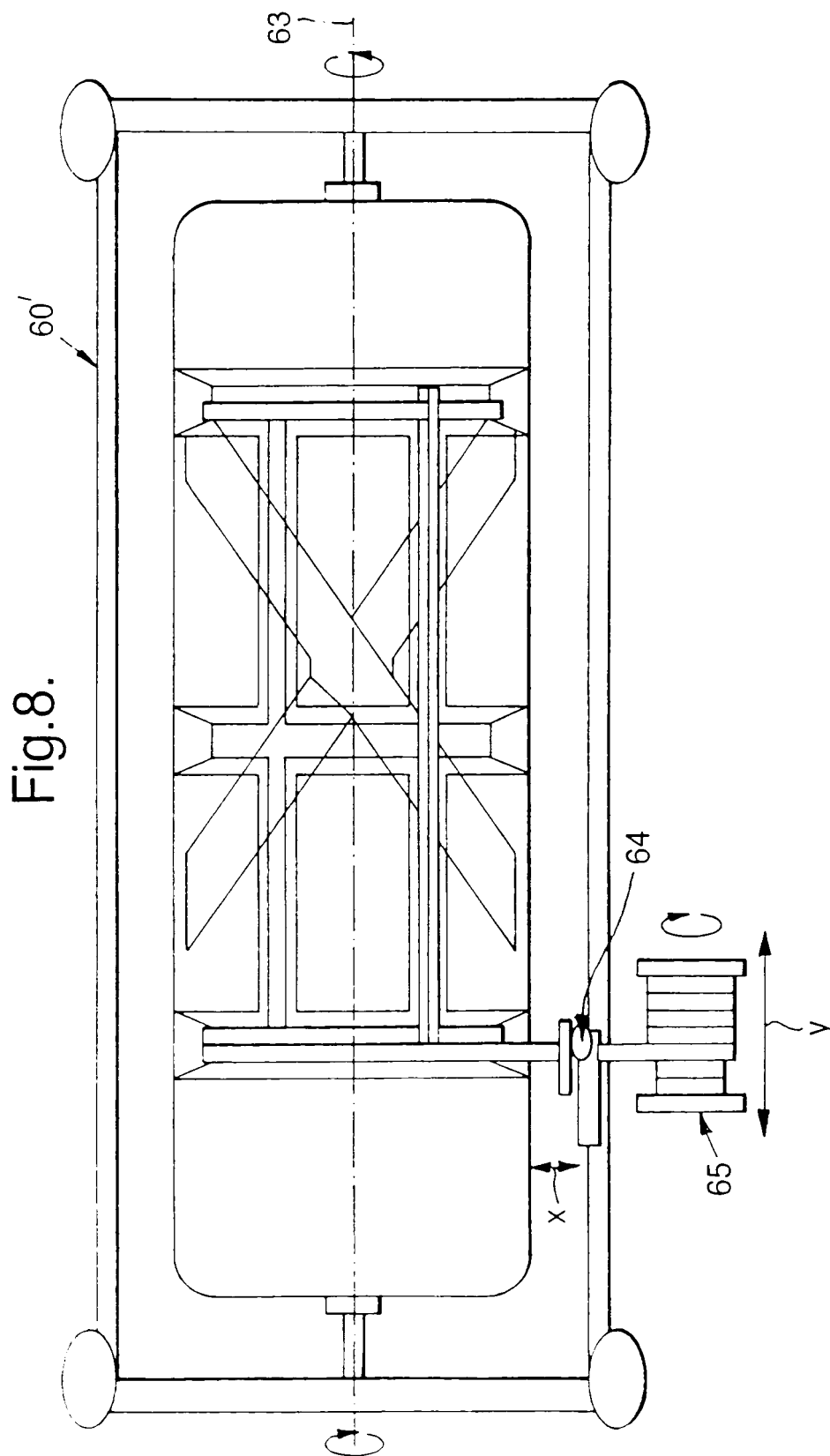


Fig.7.





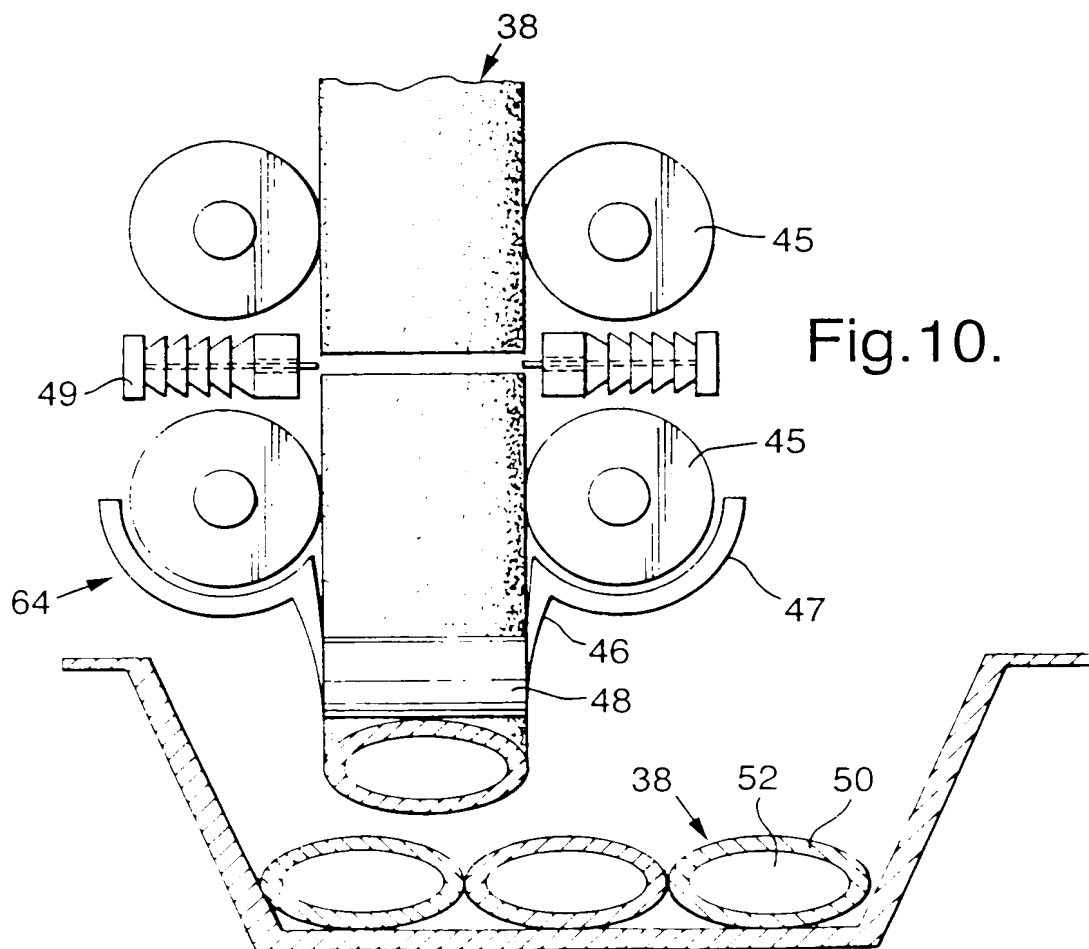
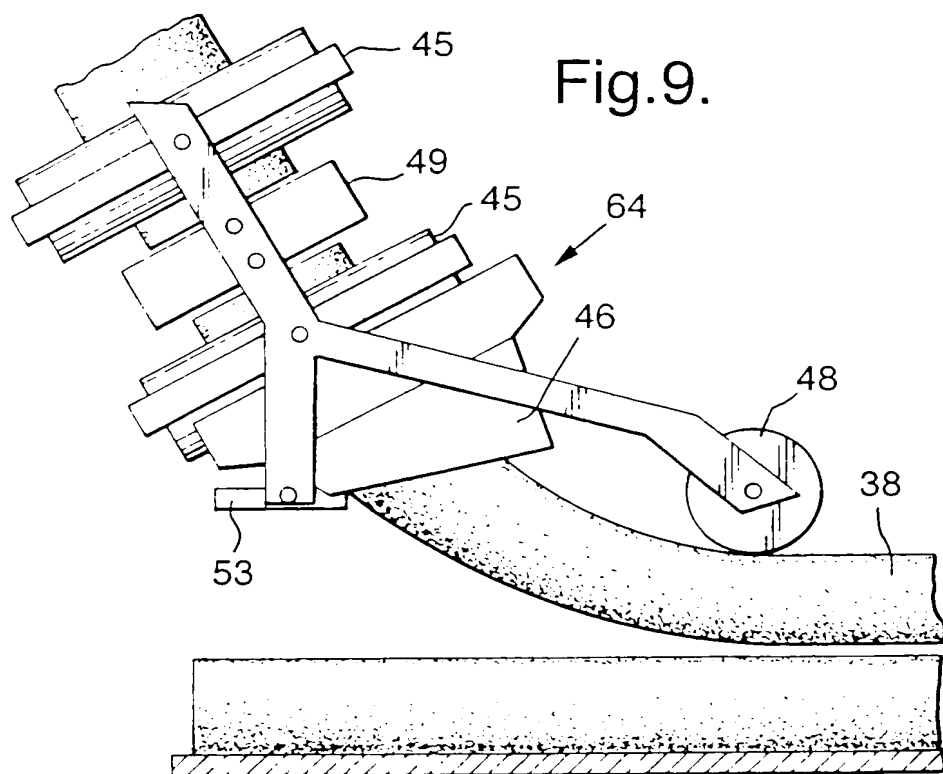


Fig.11.

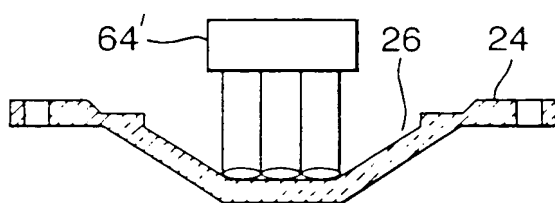


Fig.12.

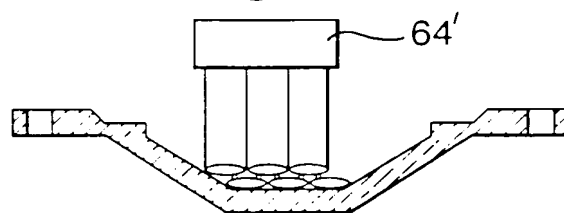


Fig.13.

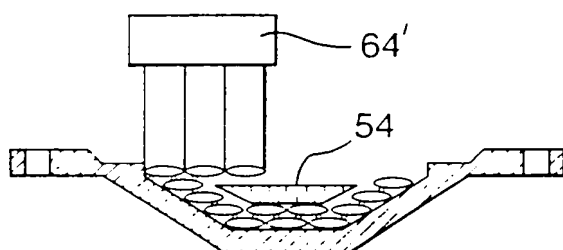


Fig.14.

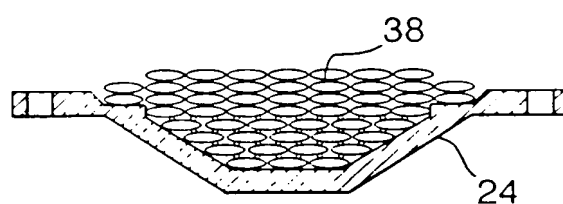


Fig.15.

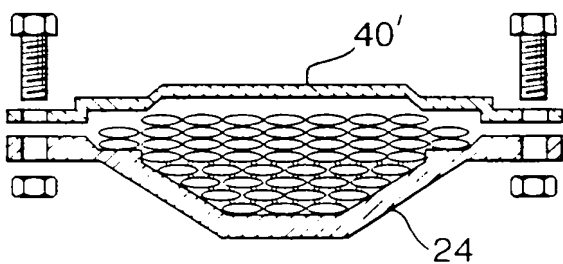


Fig.16.

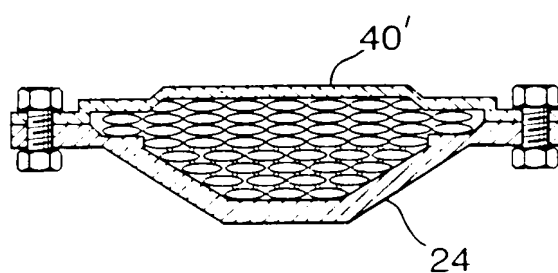


Fig.17.

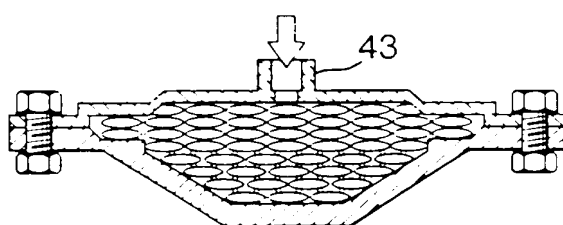
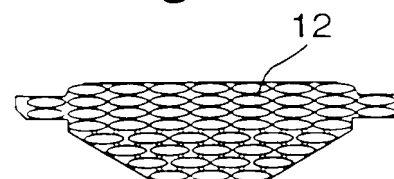


Fig.18.



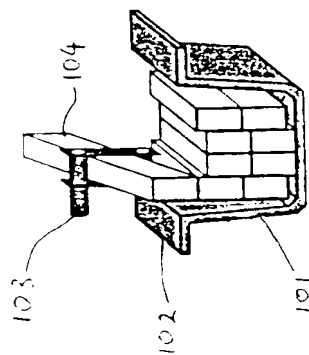


Fig. 19

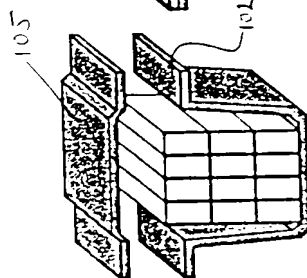


Fig. 20

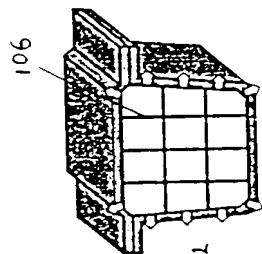


Fig. 21

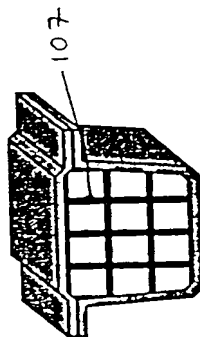


Fig. 22

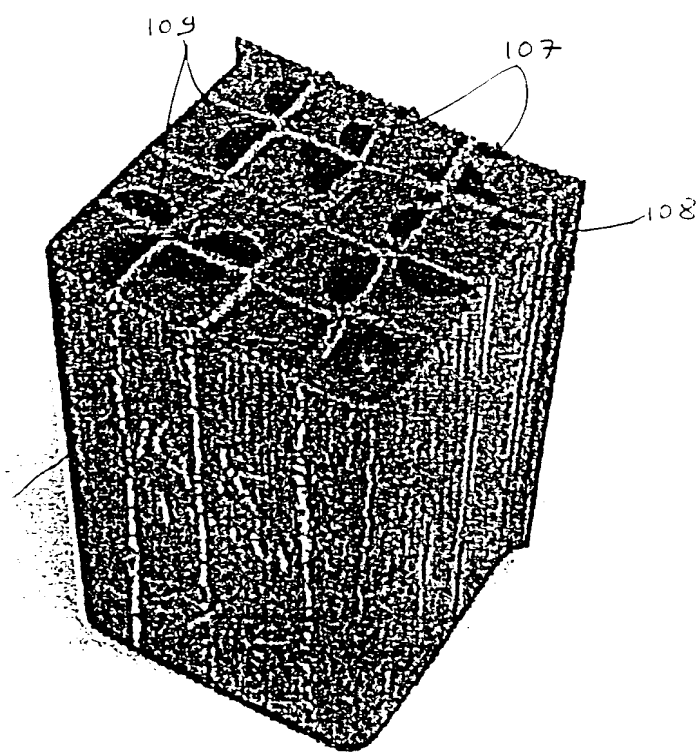


Fig. 23

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/GB 00/03279

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B29D28/00 B29C70/38 C08J9/228 B29C44/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B29D B29C A63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	GB 1 373 344 A (SECR DEFENCE) 13 November 1974 (1974-11-13) the whole document ---	1,3-6
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A	US 4 137 354 A (MAYES JR JAMES T ET AL) 30 January 1979 (1979-01-30) figures 1,15 ---	7
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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

2 January 2001

Date of mailing of the international search report

12.01.01

Name and mailing address of the ISA

European Patent Office, P.B. 5816 Patentlaan 2
NL - 2280 HV Rijswijk
Tel: (+31-70) 340-2040, Tx: 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Foulger, C

INTERNATIONAL SEARCH REPORT

Intern. Application No.

PCT/GB 00/03279

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 212 461 A (CECKA ANDREW M ET AL) 15 July 1980 (1980-07-15) column 3, line 25 -column 4, line 22; claims 1-3; figure 4 ---	12-16
X	US 4 399 992 A (MOLITOR ROBERT P) 23 August 1983 (1983-08-23) column 5, line 29-38; claim 1; figures 3-6 ---	12-16
X	EP 0 270 462 A (SONOCO GUNTHER) 8 June 1988 (1988-06-08) column 3, line 10-27; figures 1-12,14-16 column 4, line 31-36; claims 1-30 ---	12,13,15
X	FR 2 462 266 A (TECH VERRE TISSE) 13 February 1981 (1981-02-13) claims 1-6; figure 1 ---	12-15
A	US 3 936 336 A (PHILLIPS LESLIE NATHAN) 3 February 1976 (1976-02-03) figure 1 -----	12,14

INTERNATIONAL SEARCH REPORT

international application No.
PCT/GB 00/03279

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. Claims: 1-7 and 8-11

Method claim 1 discloses a method of moulding a reinforced nodal structure which includes laying down a cored reinforcement of constant cross section in and along the channels of a nodal mould and across the nodes thereof.

Device claim 8 relates to a machine for laying down reinforcement for a composite moulded nodal frame structure.

2. Claims: 12-15 and 16

Product claim 12 discloses an elongated cored reinforcement of constant cross-section for forming a composite moulded article, the reinforcement comprising an envelope of strength-giving fibres surrounding a core of expansible material.

Method claim 16 relates a method of moulding a composite article which comprises laying in a mould at least one length of a reinforcement, closing the mould to cause expansion of the reinforcement to reduce void space within and around the reinforcement, and curing resin deposited around the reinforcement.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB 00/03279

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